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B29C 45/00

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(56) Documents Cited
US 4690969 A
WPI Abstract Accession No 94-337820/42 & JP6262648A(DUPONT) 20.09.94 (see abstract) WPI Abstract Accession No 91-320637/44 & JP3213317A (IDEMITSU) 18.09.91 (see abstract)

(58) Field of Search
UK CL (Edition O) B5A AB3 ADX AD27 AMA AMC AT14B
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(54) Injection moulding apparatus

(57) An injection moulding apparatus 20 comprising a mould cavity 22 having an inlet 30 for injection of mouldable material, and a region 14 in which at least two flow fronts of mouldable material meet in use, wherein means 36 is provided for generating ultrasonic vibrations in said region in use.

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1995

Fig. 1

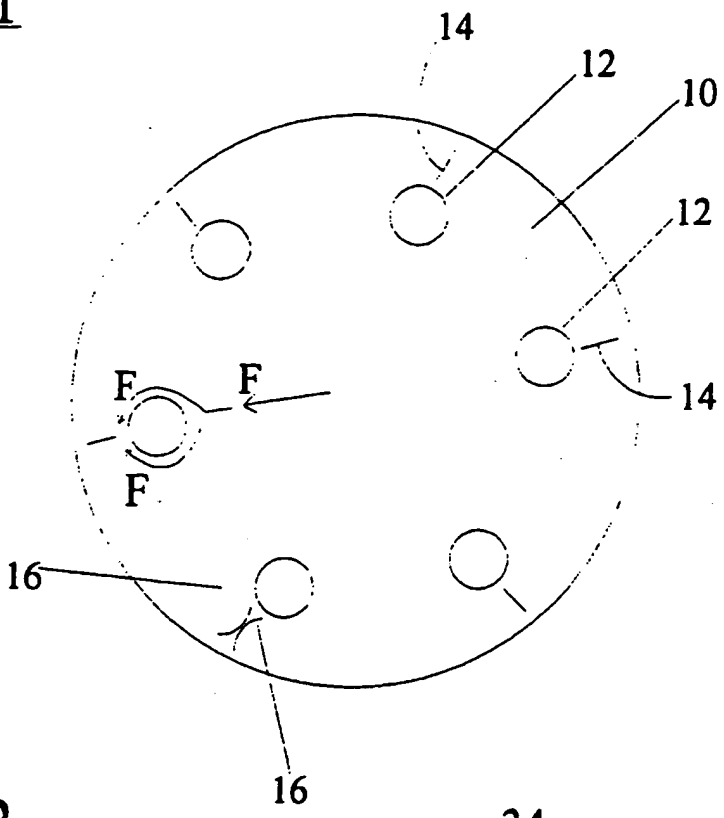

14
12
10
12
F
F
F
14
16
16

Fig. 2

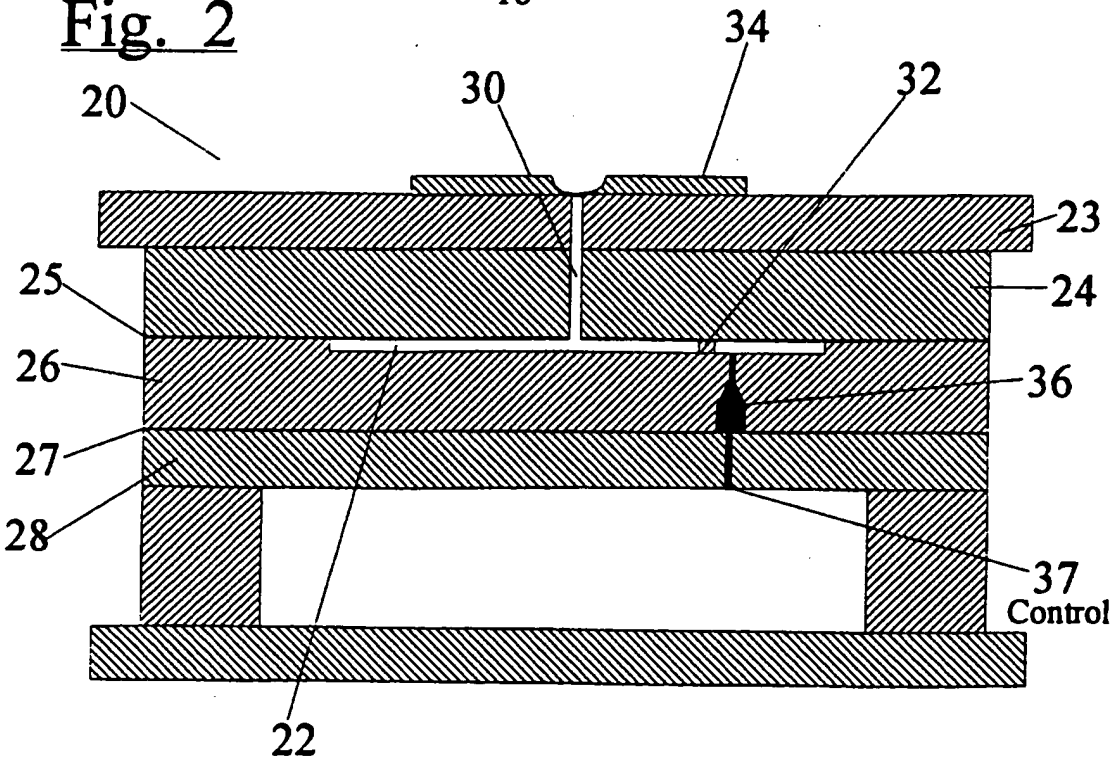

20
30
34
32
23
25
24
26
36
27
28
37
Control
22

Fig. 3

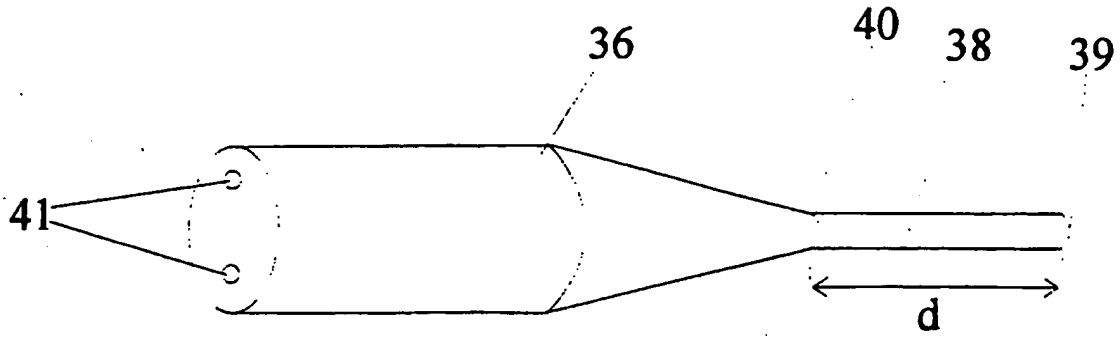
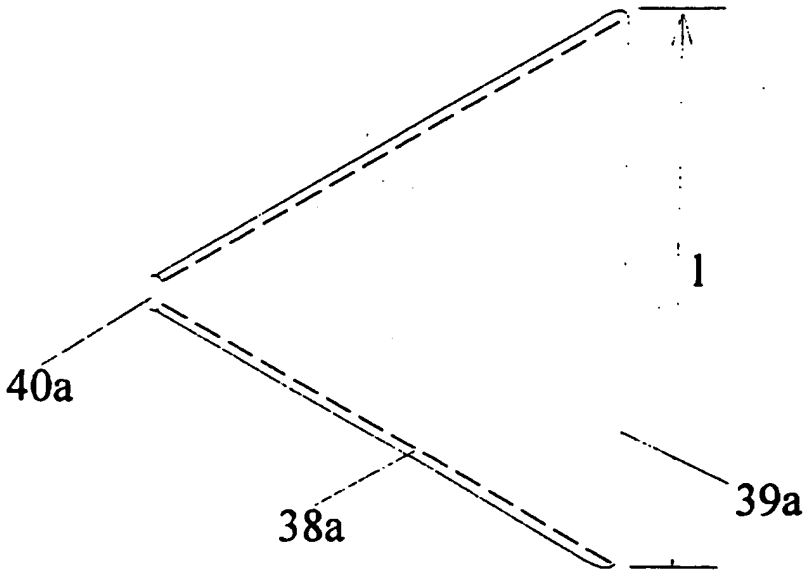


Fig. 4



APPARATUS AND METHOD OF INJECTION MOULDING

The invention relates to apparatus and method of injection moulding of materials such as thermoplastics like polymers and polymer matrix composites. In particular, the invention relates to an apparatus and method which mitigate against the formation of weld lines at converging flow fronts of molten materials in a mould.

In known injection moulding apparatus it is common to obtain internal and surface deformation in the moulded product. This deformation reduces mechanical properties and aesthetic qualities of the moulded product. These defects are known as weld lines and form when two or more converging flow fronts meet. For example, in forming a wheel trim for a car wheel, it is known to injection mould the wheel trim in a mould having a centrally located injection sprue through which the molten plastics is injected. Inserts in the moulding cavity are used to create features such as apertures within the wheel trim to enhance the appearance thereof. However, these inserts create a divergence in the radial flow of the molten material thereby causing two separate flow fronts eventually to abut on the outermost side of the mould insert.

A known system for trying to prevent such weld lines is described in the January 1994 edition of the magazine "Polymer Processing" at pages 7-9. The authors, P.S. Allan and M.J. Bevis, describe a system comprising a heater and two pumped feed paths.

Two pumps effect oscillation of two opposing flow fronts along the feed paths and the heater heats the interface region to effect a macroscopic shear which re-aligns the polymer at the surface of the mould when the mould surface is at an elevated temperature. However, the system is relatively complex in that it requires multiple pumping systems for several injection inlets into the mould to control the feed of plastics.

An object of the invention is to avoid or at least mitigate the problems of the prior art. According to one aspect of the invention there is provided injection moulding apparatus comprising a mould cavity having an inlet for injection of mouldable material, and a region in which at least two flow fronts of mouldable material meet in use, wherein means is provided for generating ultrasonic vibrations in said region in use. Beneficially, the ultrasonic vibrations can enable enhanced diffusion of molecules of the mouldable material at the interface of the two flow fronts thereby enhancing mechanical properties of the material at the flow front and also the surface structure thus improving the aesthetic qualities of the moulded product.

Preferably, the ultrasonic vibration means comprises an ultrasonic transducer preferably operable in the 20 kHz frequency range. Additionally, the transducer can comprise means for conveying ultrasonic vibration to the desired region of the

moulding cavity such as a horn. In one preferred embodiment the horn is cylindrical in shape whilst in another preferred embodiment the horn has a substantially triangular section along its longitudinal axis. Beneficially the end of the form can abut or be proximal to the interface region in the moulding cavity.

An embodiment of the invention will now be described, by way of example only, with reference to the following drawings, in which:-

Figure 1 is a schematic plan view of a known wheel trim;

Figure 2 is a schematic cross-sectional, side elevation view of an injection moulding apparatus according to the invention;

Figure 3 is a schematic perspective view of an ultrasonic transducer and horn for use in the apparatus shown in Figure 2; and

Figure 4 is a schematic perspective view of an ultrasonic horn according to a second embodiment of the invention.

Referring to figure 1, there is shown a wheel trim 10 which had been formed using a

mould having a single injection sprue which allows molten mouldable material such as plastics to be injected into a moulding cavity. The material is injected approximately centrally of the trim 10, thereby effecting radial flow of molten material throughout the cavity. Inserts in the cavity create apertures 12 since no plastic material passes into these regions during the moulding process. The inserts in the moulding cavity however, cause two flow fronts, as indicated by arrows F about an aperture 12, to form during the moulding process. The flow fronts abut one another on the radially outermost side of an insert, thereby causing weld lines 14 and 16 on the upper surface of the moulding 10 as well as internal structural irregularities beneath the surface of the moulding.

Figure 2 shows a schematic side elevation view of moulding apparatus 20 according to the invention comprising upper plates 23 and 24 wherein the latter abuts a first lower plate 26 along a split line 25 adjacent to a moulding cavity 22. First lower plate 26 also abuts a second lower plate 28 along a split line 27. An inlet sprue 30 is provided through upper plates 23 and 24 into cavity 22. The outermost end of sprue 30 is positioned in a locating ring 34. An insert 32 in cavity 22 effects the formation of an aperture in a moulding created using apparatus 20. The apparatus 20 further comprises an ultrasonic transducer 36 and a control system 37 therefor. The transducer 36 is located in a suitably shaped recess within lower plate 26 and is held

in position by abutment with second lower plate 28 having a through bore to allow connection to control 37. The ultrasonic transducer can operate at 20 kHz and have a 60 micron amplitude of oscillation. During the moulding process, the transducer can be activated at a power rating of about of 2 kW, for a time period in the order of 500 ms.

The transducer 36 is shown in more detail in figure 3 where it can be seen that the transducer 36 is connected via wires 41 at one end to control 37 and to an ultrasonic horn 38 at the other end. The horn 38 has a length d, between end faces 39 and 40, which should be integral multiples of half-wavelengths of the operational frequency. Accordingly $d = n\lambda/2$.

In use, molten mouldable material is injected through sprue 30 into cavity 22 and therefore disperses outwardly from the lower end of sprue 30 in cavity 22. Insert 32 within the cavity 22 causes two flow fronts to move around the insert. The flow fronts abut in the region of the cavity 22 adjacent to transducer 36. In order to mitigate against the surface weld lines, the ultrasonic transducer 36 is activated thereby to enhance diffusion at the interface of the two flow fronts. After moulding is complete, upper plates 23 and 24 can be removed from plate 26 along split line 25 thereby to remove a moulding from cavity 22.

Figure 4 shows an alternative embodiment of a horn for the ultrasonic transducer according to the invention. The horn 38a is substantially an axial section through a conical frustrum; that is having an end 40a for abutment with transducer 36, a body having a triangular section along its longitudinal axis and an elongate end face 39a. The length of face 39a can be as long as the interface region of the flow fronts in the cavity.

Beneficially, the ultrasonic technique eliminates weld lines in a moulded component both in the bulk material and at the surface. The ultrasonic energy can be directed specifically to regions where weld lines would otherwise form. Preferably, the tip of the ultrasonic horn actually contacts the mouldable material such as thermoplastic in a cavity, but can be slightly withdrawn therefrom.

CLAIMS

1. An injection moulding apparatus comprising a mould cavity having an inlet for injection of mouldable material, and a region in which at least two flow fronts of mouldable material meet in use, wherein means is provided for generating ultrasonic vibrations in said region in use.

2. Apparatus according to claim 1 wherein the ultrasonic vibration means comprises an ultrasonic transducer.

3. Apparatus according to claim 2 wherein the transducer is operable in the 20 kHz frequency range.

4. Apparatus according to claim 2 or 3 wherein the transducer comprises means for conveying ultrasonic vibration to the desired region of the moulding cavity.

5. Apparatus according to claim 4 wherein the conveying means is a horn.

6. Apparatus according to claim 5 wherein the horn comprises a cylindrically shaped portion.

7. Apparatus according to claim 5 wherein the horn comprises a section which is substantially triangular along its longitudinal axis.

8. Apparatus according to claim 5, 6 or 7 wherein the horn abuts or is proximal to the interface region in the moulding cavity in use.

9. Apparatus according to any one of claims 5 to 8 wherein the horn has a substantially rectangular end face proximal the interface region.

10. Apparatus according to any one of claims 5 to 8 wherein the horn has a substantially circular end face proximal the interface region.

The Patent Office

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Application No: GB 9521622.2 **Examiner:** Monty Siddique
Claims searched: 1-10 **Date of search:** 26 June 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B5A (AB3, ADX, AD27, AMA, AMC, AT14B)

Int Cl (Ed.6): B29C 45/00

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US 4690969 (TORAY...)	1 at least
X	WPI Abstract Accession No 94-337820/42 & JP6262648A (DUPONT) 20.09.94 (see abstract)	1 at least
X	WPI Abstract Accession No 91-320637/44 & JP3213317A (IDEMITSU) 18.09.91 (see abstract)	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.